Nuclear Pipe Inspection Robot

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Aim

- Develop a pipe in bore articulated inspection robot (PIBAIR) - capable of navigating a 2-inch pipe network.
- The system must be able to map radioactive contaminants for the decommissioning of Sellafield nuclear power station.

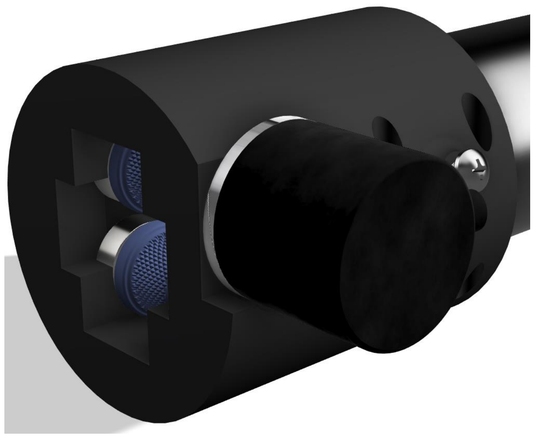
Responsibilities

The following contributions were made towards the Real Robotics research project:

1. Miniaturise Control Electronics
2. Integrate Radiation Sensor
3. Develop a Mapping System
4. Program a Control Graphical User Interface (GUI)
5. Select PIBAIR Hardware
6. Radiation Resistance Testing

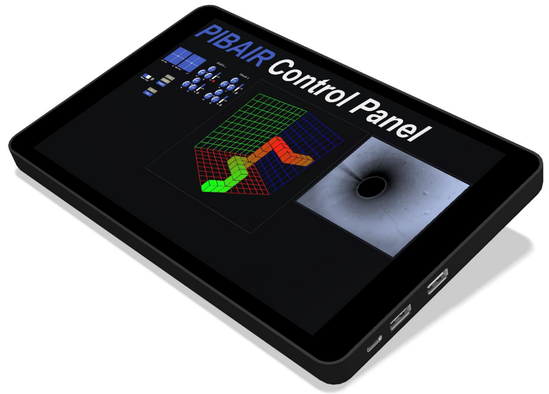
② Tether Encoder

- The encoder measures the distance that the tether is pulled into the pipe by the robot modules.
- This tether encoder housing attaches to the end of the pipe and the roller spacing can be adjusted to allow the tether USB redriver chip through.



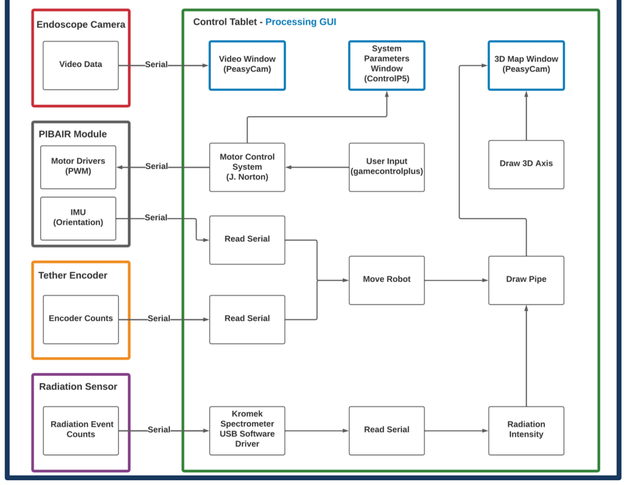
④ Control Tablet

- A Linux based touchscreen tablet enables the control of PIBAIR from a single handheld device.
- It runs USB drivers to interface with the radiation sensor to map the radiation intensity in real-time.
- The tablet is powered by a Raspberry Pi Compute Module 4. A GUI displays a 3D map of the pipe network, the system parameters and a live video feed.



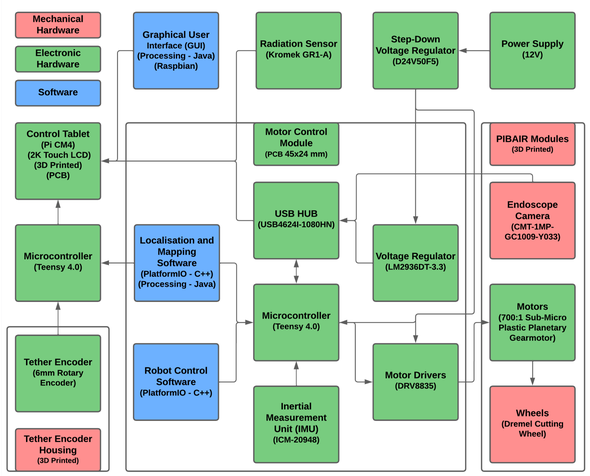
⑤ Software Architecture

- The GUI was developed using the Processing graphical library and IDE.
- The microcontrollers, camera and radiation sensor interact with the GUI through USB serial communication.



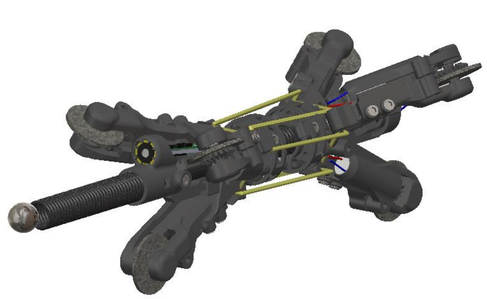
① System Design

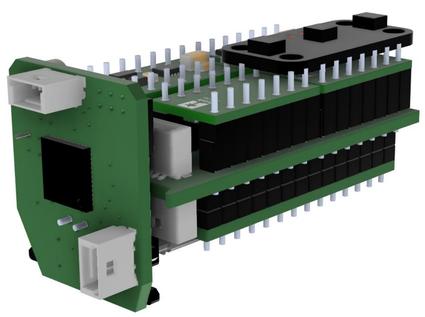
- Hardware was selected and designed to enable control of PIBAIR over a 30-meter tether.
- The hardware enables video data to be streamed back to a touch screen tablet where multiple robot modules can be controlled simultaneously.



③ Motor Control Module

- To increase PIBAIR's range, the motor driver electronics were miniaturised onto a custom PCB that can fit inside the pipe behind each robot module.
- An inertial measurement unit on the PCB senses the robot's orientation which is then combined with tether encoder data to map the pipe network.

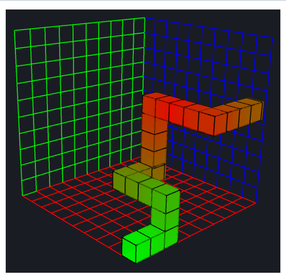




- USB hub chips allow multiple motor control modules, an endoscope camera, and a radiation sensor to communicate across the same tether.
- The PCB has four dual motor driver carrier boards connected to a microcontroller, which drives each robot module with eight motors.

Conclusion

- The motor control electronics have been miniaturised into control modules which are connected via USB.
- Multiple PIBAIR robots can work collaboratively to pull the radiation sensor through a pipe network.
- The PIBAIR system can be controlled from a tablet.
- A GUI has been developed to display video, 3D mapping and radiation intensity data.
- Preliminary testing of the mapping system achieved an accuracy of up to ± 0.6 cm.



Future Developments

1. Further testing with a radiation sensor in a large pipe network is planned to take place at the University of Bristol's Fenswood facility.
2. Radiation resistance testing at the University of Bristol's Hot Robotics facility.
3. Commercialisation of the PIBAIR system for use at Sellafield nuclear power station.